Evaluation of an experimental ensemble forecast system with the CTM CHIMERE, using the 50 members of the operational ECMWF EPS forecasts as NWP input

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1 Abstract

Meteorological fields have an important influence on the production of ozone and other species when incorporating those data fields into a CTM. Elevated pollutant concentrations (e.g. ozone, PM10, NO2, are harmful for the health of people and some species can have a negative influence on crop production. In orer to make reliable forecasts which can give the policy maker an instrument to make the right decisions on days when a pollution event may occur, it is interesting to make an ensemble forecast of the pollutant species under consideration in order to obtain a number, which gives you the uncertainty of your forecast. An evaluation of an ensemble pollutant forecast system has been established, using the CTM CHIMERE (Vautard et al, 2001). This model was forced by ECMWF meteorological fields (50 EPS members) and by the EMEP emission database. The simulation domain covers Western Europe with a spatial resolution of 0.5 degree. We also introduce an extreme pollution EPS system that only uses a transport length calculated solely from the meteorological fields to predict unfavorable conditions for the dispersion of air pollutants. Preliminary results suggest that for forecasting whether an extreme pollution event will occur or not, it might be of comparable quality to the more advanced CHIMERE-EPS. However, more data is needed to draw solid conclusions. Moreover, the probability forecasts of both systems are fairly unreliable when taken at face value. In order to be used by policy makers in real-life situations, they need to be calibrated and this also requires more data.

2 Introduction

We compare two systems for predicting extreme NO2 pollution peaks:

- EXPOL-EPS: an Ensemble Prediction System for EXtreme POLlution, based on a transport length l_T calculated solely from the meteorological fields of the ECMWF EPS, given by (see Termonia and Quinet, 2004).

$$l_T = \overline{u}/\mu\,, \qquad (1)$$

  where $\overline{u}$ is the wind speed and μ the Brunt-Vaïsälä frequency. The transport length is only defined for a stable atmosphere.
  For each member, an alert is given when there exists a layer at the surface where $l_T < 125$ for a period of at least $24h$, and during which the thickness of the layer is bigger than (rougly) $105m$ for a period of at least $12h$. The more members given an alert, the higher the probability of an extreme pollution event.
  A plot of the transport length for one of the EPS members, on a day of an observed extreme NO2 peak, is shown in figure 1.

- CHIMERE-EPS: The CHIMERE chemical transport model, forced by the ECMWF EPS.

3 Verification

- Both models are calibrated using a logistic regression on training data and then verified on an independent dataset. The calibration period is a 5 month period, from 1/12/2007 untill 29/02/2008, and from 1/01/2010 untill 28/02/2010. The verification period is a short period with several extreme events, from 25/12/2008 until 31/1/2009.

- The (extreme) event studied is **NO2 daily maximum in Ukkel $>$ 109 μ g/m^3**.

- The predicted probabilities for this event of the different (calibrated) models for some days in the verification period is shown in table 1.

Table 1. Forecasted probabilities of the extreme event NO2 daily maximum in Ukkel $>$ 109 μ g/m^3 for tomorrow (D+0 in operational sense).

obs date	obs	EXPOL-EPS	CTM-EPS mean	CTM-EPS mean_sd
20081226	0	0.03	0.02	0.01
20081227	0	0.03	0.01	0.01
20081228	0	0.04	0.03	0.06
20081229	0	0.17	0.06	0.11
20081230	0	0.51	0.10	0.15
20081231	1	0.88	0.57	0.15
20090101	0	0.22	0.24	0.26
20090102	0	0.07	0.05	0.01
20090103	0	0.03	0.25	0.27
20090104	0	0.03	0.03	0.01

- The verication scores used are the Brier score (bs), the Brier skill score (bss), the reliability component of the Brier score (bs_reli) and the resolution component of the Brier score (bs_resol). Results for the D+0 (calibrated) forecasts are shown in tabel 2.

Table 2. Brier scores for prediction of the extreme event NO2 daily maximum in Ukkel $>$ 109 μ g/m^3 for tomorrow (D+0 in operational sense).

	Calibration period			
	bss	bs	bs_reli	bs_resol
EXPOL-EPS	0.27	0.042	0.014	0.029
CHIMERE-EPS_mean	0.29	0.041	0.014	0.031
CHIMERE-EPS_mean_sd	0.33	0.038	0.010	0.029
	Verification period			
	bss	bs	bs_reli	bs_resol
EXPOL-EPS	0.58	0.040	0.027	0.081
CHIMERE-EPS_mean	0.43	0.054	0.054	0.094
CHIMERE-EPS_mean_sd	0.38	0.058	0.045	0.081

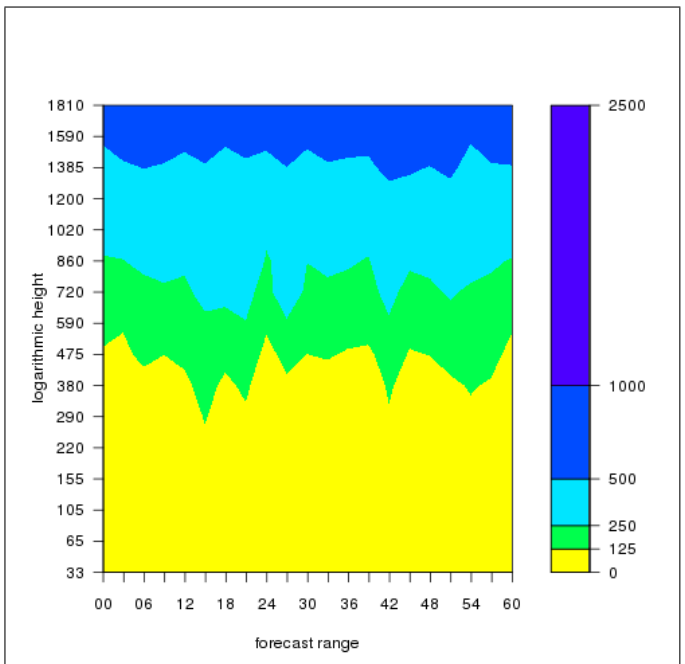

Figure 1. Transport length l_T as a function of lead time and height, for member 14 on forecast date 30/12/2008 (12Z UTC run). An extreme NO2 pollution peak was observed on 31/12/2008.

4 Conclusions

- CHIMERE-EPS forecasts of daily maximum NO2 have a substantial bias, which is naturally even larger when only looking at days of observed extreme NO2 peaks. A calibration using logistic regression can partly correct this.
- For CHIMERE-EPS, the ensemble mean (of daily maximum NO2) is a good predictor of extreme (NO2) pollution. Using the ensemble spread as predictor as well, adds little to the resolution, but might improve the reliability.
- The 1-day ahead (D+0 in operational sense) extreme NO2 pollution forecasts of EXPOL-EPS and the more calculation-intensive CHIMERE-EPS are of comparable quality, with perhaps EXPOL-EPS being more reliable and CHIMERE-EPS having slightly better resolution.
- The 2-day ahead (D+1 in operational sense) extreme NO2 pollution forecasts of EXPOL-EPS are probably less good than those of CHIMERE-EPS. The EXPOL-EPS forecasts seem to decrease in quality after 1 day (not shown).
- More data is needed to draw firm conclusions. We plan to use reforecasts.

Acknowledgement

The authors would like to thank IRCELINE for providing the ozone and PM10 data

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Part of this study was funded by the Belgian Federal Public Services for Science Policy, through the program for research and sustainable development, Research projects MO/34/016 and SD/HE/01A.

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International WORKSHOP on Air Quality Forecasting Research,29 Nov - 1 Dec, 2011, Washington DC - USA